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Authors*: Rodrigo Caputo, Juan Pablo Medina and Claudio Soto

Affiliation: Central Bank of Chile

Email: rcaputo@bcentral.cl, jpmedina@bcentral.cl, csotog@bcentral.cl.

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Understanding the Impact of the Global Financial Shock on the Chilean Economy*

Rodrigo Caputo †
Central Bank of Chile

Juan Pablo Medina ‡
Central Bank of Chile

Claudio Soto §
Central Bank of Chile

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Abstract

In this paper we analyze empirically the consequence of the global financial crisis in the Chilean economy. We estimate a small open economy DSGE model extended to incorporate financial frictions. Our results indicate that financial shocks played a major role in explaining the downturn in activity in Chile in 2009. Other domestic shocks, such as demand or productivity shocks did not have a relevant impact during this period. Using the estimated model, and the inferred shocks, we analyze the consequences of alternative policy rules. In particular, we consider a rule that reacts more aggressively to output fluctuations, and another that incorporates a systematic policy response to financial market innovations. The conclusion of these exercises is that in both cases monetary policy would have been more efficient at avoiding the contraction in activity. In doing so, the fall in inflation would have been less and the equilibrium nominal interest rate would have fall by less. This implies that the risk of reaching the zero lower bound for the interest rate would have been muted.

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†rcaputo@bcentral.cl

‡jpmedina@bcentral.cl

§csotog@bcentral.cl

1 Introduction

During 2008-09 we witnessed a period of unprecedented financial turmoil, which led to a major financial crisis and a global recession. After the failure of Lehman Brothers in September 2008, uncertainty spread in financial markets around the world. There was a sudden contraction in liquidity, and different financial spreads spiked. In the case of emerging market economies, there was a flight-to-quality episode, which led to an abrupt depreciation of local currencies. Central banks in these economies and in developed countries responded by lowering their monetary policy rate in a substantial amount. In the case of Chile, despite an aggressive monetary and fiscal policy reaction, there was a sizable contraction in domestic demand and a mild recession that lasted for about a year (GDP fell by 1.7% in 2009). This, despite the fact that no major disruption in the financial market occurred.

In this paper we analyze empirically the consequence of the global financial crisis and recession in the Chilean economy. To encompass the different channels through which this event affected the business cycle in this country, we estimate a DSGE model for a small open economy that incorporates financial frictions. Our focus is quantitative rather than qualitative, in the sense that we intend to quantify the contribution of different shocks on activity. The model is a standard new Keynesian DSGE model as in Gali and Monacelli (2005). We extend the model by incorporating a financial shock that affects the lending rate at which households are able to borrow domestically. This financial shock, which is not derived from first principles in our model, captures all the innovations in the domestic financial market that affect the interest rate faced by borrowers. We also include an external financial shock that affects the cost at which domestic agents are able to borrow in the international financial markets. Other shocks in the model include productivity shocks, autonomous demand shocks and monetary policy shocks.

The estimation of the model is performed using a standard Bayesian approach. As observable variables we include GDP, Consumption, core inflation, the domestic policy rate, the Libo rate, the EMBI and a measure of the domestic lending spread. Given the estimated parameters of the model, we obtain that a domestic financial shock leads to a contraction in activity and a fall in inflation. By contrast, a financial shock that affects foreign borrowing leads to a contraction in activity and an increase in inflation in response to the nominal depreciation of the currency. The two financial shocks (domestic and external) are assumed to follow an AR(1) process each, with no cross-correlation. For most part of the sample it is possible to assume that the domestic financial shock genuinely responded to local innovation (domestic risk assessment). However, the domestic spread increased dramatically just after the Lehman collapse. This reaction was obviously triggered by the global financial turmoil. There are several explanation for this increase in domestic financial spread. This could have reflected the evaluation of domestic lenders (banks) that borrower's risk would increase as a consequence of a likely contraction in activity. It could have also being caused by the increase in the cost of foreign funding that is relevant to domestic financial intermediaries. Finally, in the case of Chile, some large financial players are subsidiaries of European banks that were exposed to toxic assets. Therefore, there were some serious concern of possible contagion effects.

Our results indicate that an important share of the fall in Chile's GDP during 2009 was due to the contraction in global demand, which affected exports. However, both the external and the domestic financial spreads had a major impact on activity. The domestic financial shock explains a bit more than a third of the fall in activity, whereas the external financial shock explains another third. No major role played autonomous shocks to demand or productivity shocks.

We perform some robustness checks to our results. First, we allowed the financial shocks (domestic and external) to be governed by a transitory process and by a persistent process. This is motivated in the fact that at the beginning of the crisis there was great uncertainty regarding the possible duration of the turmoil. By assuming these two processes for each financial shock, we allow the data to infer at each moment in time which type of shock is hitting the economy: a transitory or a persistent shock. Turns out that the estimation procedure identifies large innovations in the persistent component of the financial shocks right after the Lehman collapse. In turn, these innovation are the ones that have the larger impact on activity. Second, we modify the set of observable variables. In both cases the basic conclusions remain: financial shocks had a major impact in explaining the fall in activity, and other domestic shocks played a minor role.

Using the estimated model and the infer shocks we ask ourself what would have happen during the crisis if the monetary policy would have been conducted in a different way. In particular, we consider two alternative rules: one that is more aggressive responding to output fluctuations, and another that reacts to financial market innovations. The conclusion of these exercises is that in both cases monetary policy would have been more efficient at avoiding the contraction in activity. In doing so, the fall in inflation would have been less and the equilibrium nominal interest rate would have fall by less. This implies that the risk of reaching the zero lower bound for the interest rate would have been muted.

The paper is organized as follows. In Section 2, we lay down a small open economy DSGE model containing real and nominal rigidities. This model incorporates an exogenous financial friction that generates a deviation of the market rate from the monetary policy rate. It also takes into account the effects of an exogenous country risk premium shock. Section 3 describes the Bayesian methodology used in the estimation. Section 4 presents the results in the baseline scenario, and discusses the implications of an alternative ways of modelling the spread and country risk premium innovations. In this part, we also consider the implications of two alternative policy rules. Section 5 concludes.

2 The Model

In this section we describe the dynamic stochastic general equilibrium (DSGE) model we use. Our model is a small open economy one with nominal and real rigidities that follows closely Galí and Monecelli (2005) . It is a simplified version of the model developed by Medina and Soto (2005) for the Chilean economy.

We depart from the standard modelling approach in this area, by assuming transitory deviations of the market short-term interest rate from the monetary policy rate. The spread between these two rates broadly captures different innovations in the financial market that affect the preference for liquidity and the perceived risk.[1]

On the other hand, the first order conditions of our model imply that the UIP condition holds. In this case expected devaluation can be explained by the interest rate differential, as well as by an endogenous risk premium component, that depends on the net foreign asset position of the economy. We allow for the possibility of exogenous country risk premium shocks. Those may reflect global movements in country premiums unrelated to the state of the economy.

In our model interest rate spread shocks as well as country risk premium innovations will have an impact consumption, output and inflation. The assumption throughout this paper is that both types of shocks are uncorrelated to the state of the economy and to monetary policy decisions.

The domestic economy is open and it is small for the rest of the world. The latter assumption implies that international prices, the foreign interest rate and foreign demand are not affected by domestic agents' decisions. Prices and wages are sticky. They are optimally adjusted infrequently, and they are partially indexed to past inflation. The introduction of wage rigidities together with price rigidities is very important in our model not only because it increases the realism of the model but because it implies a stronger trade-off between inflation and output fluctuations (see Erceg *et al.*, 2000, and Blanchard and Galí, 2005).[2]

Domestic households consume domestically-produced goods (Home goods) and imported differentiated goods (Foreign goods). Both types of goods are imperfect substitutes in the consumption basket. We assume that consumption exhibits habit formation. Households, on the

[1]Some recent papers, notably Cúrdia and Woodford (2010) and Gerali et al (2010) have provided microfundations for this spread and have analyzed the optimal policy response to this type of financial shocks in closed economies. In our DSGE model, financial shocks are exogenous and orthogonal to monetary policy shocks.

[2]Blanchard and Galí emphasize that price rigidities alone does not imply a conflict between output gap and inflation stabilization –what they call the *divine coincidence*. They show that adding wage rigidities breaks down this *divine coincidence*.

other hand, supply a differentiated labor service and receive the corresponding wage compensations. Each household has a monopolistic power over the type of labor service it provides. Furthermore, households are the owners of firms producing Home goods, and therefore, they receive the income corresponding to the monopolistic rents generated by these firms.

Domestic firms produce differentiated varieties of Home goods. For simplicity, we assume that labor is the only variable input used for production. These firms have monopolistic power over the variety of goods they produce. We assume that productivity is subjected to stochastic shocks and grows at a rate g_y in steady state. Home goods are partly sold domestically and partly exported.

Monetary policy is modelled as a Taylor-type rule that incorporates interest rate inertia. In particular, the interest rate reacts to inflation, GDP growth and its own lagged value. Finally, we also assume that in the steady state, the inflation rate is exogenously determined by the monetary authority (the inflation target).

In what follows, we present the log-linearized version of the model. Further details on the model can be found in Medina and Soto (2005).

2.1 Aggregate Demand

Domestic households consume *Home* (domestically produced) and *Foreign* (imported) goods. We assume the utility function exhibits habit formation in consumption. Let c_t be the log deviation of consumption from its steady-state level. The Euler equation for consumption is given by:

$$c_t = \frac{1}{1+h} E_t c_{t+1} + \frac{h}{1+h} c_{t-1} - \frac{1-h}{1+h} \sigma_c (\widetilde{i}_t - E_t \pi_{t+1}) + \frac{1-h}{1+h} (1-\rho_c) \zeta_{c,t} \tag{1}$$

where h is the parameter in the utility function that captures the degree of habit formation in consumption. The σ_c coefficient is the elasticity of intertemporal substitution and $\widetilde{i}$ is the market interest rate. On the other hand, $\zeta_{c,t}$, represents a preference shock that follows an AR(1) process, with a persistence coefficient of ρ_c.

Domestic consumption of Home ($c_{H,t}$) and Foreign ($c_{F,t}$) goods depends on the level of total consumption and the relevant relative price in the following way:

$$c_{H,t} = c_t - \eta pr_{H_D,t} \tag{2}$$

$$c_{F,t} = c_t - \eta pr_{F,t} \tag{3}$$

where $pr_{H_D,t}$ is the relative price of Home goods (relative to the CPI) sold domestically, and $pr_{F,t}$ is the relative price of Foreign goods. Parameter η is the elasticity of substitution between Home and Foreign goods .

Exports are given by the foreign consumption of Home goods, $c_{H,t}^{*}$. They depend on the relevant relative price as well as on the aggregate level of foreign consumption in the following way:

$$c_{H,t}^{*} = \gamma \left(y_t^{*} - \eta^{*} \left(pr_{H_F,t} - rer_t \right) \right) + (1-\gamma) y_{t-1}^{*} \tag{4}$$

where $pr_{H_F,t}$ is the relative price of Home goods sold abroad, $rer_t = e_t + p_{F,t}^{*} - p_t$ is the real exchange rate, and η^{*} is the price elasticity of foreign demand for Home goods. Foreign total consumption, y_t^{*}, is exogenously given. The above specification assumes that a fraction of exports depend on past values of foreign consumption. This tends to reflect the fact that the expenditure switching effect takes time to materialize. In fact, exports react to relative price changes and world output, but they do with some lags. The γ coefficient is in the range (0,1).

Variable $\widetilde{i}_t$ in equation (1) is the *market* short-term lending nominal interest rate, and $\widetilde{i}_t - E_t \pi_{t+1}$ corresponds to the *ex-ante* real market interest rate. We assume that the market rate may deviate from the monetary policy rate, i_t:

$$\widetilde{i}_t = i_t + \zeta_{\widetilde{i},t} \tag{5}$$

Deviations of the market rate from the policy rate are triggered by innovations to $\zeta_{\widetilde{i},t}$, which captures different risk premia embedded in the market rate. In order to isolate the effect of changes in financial conditions, we assume that financial shocks innovations are exogenous and unrelated to the state of the economy.

From the utility maximization problem we derive the Uncovered Interest Parity (UIP) condition ,

$$i_t = i_t^{*} + E_t \Delta e_{t+1} + \varphi_t, \tag{6}$$

where $E_t \Delta e_{t+1}$ is the expected devaluation and φ_t is the log-linear approximation of the premium domestic households have to pay each time they borrow from abroad. We consider two sources for this external risk premium. In particular, the risk premium is a function of an endogenous component, the net asset position of the economy, and an exogenous shock:

$$\varphi_t = \varrho b_t^{*} + \zeta_{\varphi,t} \tag{7}$$

where b_t^{*} is the net holding of foreign bonds by domestic households. The larger is the net holding of external bonds, the higher the probability of default and the larger is the premium charged on external borrowing. On the other hand, $\zeta_{\varphi,t}$ is innovation to the external risk premium that is assumed to be exogenous and unrelated to the state of the economy. The coefficient ϱ is the elasticity of the risk premium to the net foreign asset position of the economy.

2.2 Aggregate Supply and Inflation

There is a large set of domestic firms producing varieties of Home goods. Some firms sell their varieties in the domestic markets, while others export them. Each firm faces a constant elasticity demand for their varieties and set optimally its price when receiving a signal. The signal follows a Poisson distribution with arrival rate $1 - \phi_H$ each period. Firms that do not receive the signal follow a simple "passive" rule to update their price.[3] From this optimization problem we derive a Phillips curve for the inflation of Home goods $\pi_{H,t}$:

$$\pi_{H,t} = \frac{(1-\phi_H)(1-\beta\phi_H)}{\phi_H(1+\beta\xi_H)}\left(wr_t - pr_{H,t}\right) + \frac{\beta}{1+\beta\xi_H}E_t\pi_{H,t+1} + \frac{\xi_H}{1+\beta\xi_H}\pi_{H,t-1}$$

Parameter ξ_H captures the degree of indexation of Home goods prices, and β is the household's discount factor.

In order to introduce imperfect pass-through from exchange rate movements into inflation we assume that imported good retailers set prices *a-la* Calvo. A set of importing firms buy varieties of Foreign goods abroad and resell them domestically. Each importing firm has monopolistic power in the domestic retailing of a particular variety. They adjust the domestic price of their varieties infrequently, only when receiving a signal. The signal arrives with probability $1 - \phi_F$ each period. As in the case of domestically produced varieties, if a firm does not receive a signal it updates its price according to a passive similar to the one above. Hence, imported goods inflation can be expressed as:

$$\pi_{F,t} = \frac{(1-\phi_F)(1-\beta\phi_F)}{\phi_F(1+\beta\xi_F)}\left(rer_t - pr_{F,t}\right) + \frac{\beta}{1+\beta\xi_F}E_t\pi_{F,t+1} + \frac{\xi_F}{1+\beta\xi_F}\pi_{F,t-1}$$

where the parameter ξ_F captures the degree of indexation of imported goods prices. The consumer price index (CPI) inflation, π_t, is then given by the following expression:

$$\pi_t = (1-\alpha)\pi_{H,t} + \alpha\pi_{F,t} \tag{8}$$

where $\pi_{H_D,t}$ is Home goods inflation and $\pi_{F,t}$ is the foreign goods inflation (in domestic currency). The α coefficient is the share of foreign good in the consumption basket. We set α to 40%.

Production in the Home goods sector is characterized by firms that act as a monopoly in the production of a single variety. As explained before, each firm maximizes profits by choosing

[3] In particular, if the firm does not adjust its price between t and $t+i$, then the price it charges in $t+i$ is given by $\Gamma^i_{H,t}P_{H,t}(z_H)$, where $\Gamma^i_{H,t}$ is a function that defines the updating rule. This adjustment rule is given by $\Gamma^i_{H,t} = \prod_{j=1}^{i}(1+\pi_{H,t+j-1})^{\xi_H}(1+\overline{\pi}_{t+j})^{1-\xi_H}$ where $1+\pi_{H,t} = (P_{H,t}/P_{H,t-1})$, and where $\overline{\pi}_{t+j}$ corresponds to the inflation target set by the authority.

the price of its variety subject to the corresponding demand and the available technology. For simplicity, we assume that labor is the only variable input used for production. Hence, the log-linear approximation to the aggregate production function is given by:

$$y_{H,t} = a_{H,t} + l_t \tag{9}$$

where variable $a_{H,t}$ represents an exogenous productivity shock in the Home goods sector that is common to all firms.

We introduce nominal wages rigidities by assuming that each household has monopolistic power over the a particular type of labor service, and adjust its wage rate infrequently upon receiving a signal which arrives with probability $1 - \phi_L$ each period. From the optimal choice of wages we can obtain the following log-linear expression:

$$\begin{aligned}\frac{1 + \nu_L\phi_L + \sigma_L\epsilon_L(\phi_L + \nu_L)}{1 + \sigma_L\epsilon_L} wr_t - \phi_L wr_{t-1} - \nu_L E_t wr_{t+1} = \\ \frac{(1 - \nu_L)(1 - \phi_L)}{1 + \sigma_L\epsilon_L} mrs_t - (\phi_L + \nu_L\xi_L)\,\pi_t + \phi_L\xi_L\pi_{t-1} + \nu_L E_t\pi_{t+1}\end{aligned} \tag{10}$$

where $\nu_L = \beta\phi_L$, and where wr_t is the real wage rate, σ_L is the inverse of the elasticity of labor supply, ϵ_L is the elasticity of substitution among labor varieties, ξ_L defines the degree of wages indexation to past inflation, and mrs_t is the marginal rate of substitution between labor and consumption given by

$$mrs_t = \sigma_L l_t + \frac{1}{\sigma_c(1-h)} c_t - \frac{h}{1-h} c_{t-1} \tag{11}$$

Now, let π_t^* be the foreign inflation expressed in foreign currency. The evolution of the real exchange rate, rer_t, is given by:

$$rer_t = rer_{t-1} + \Delta e_t + \pi_t^* - \pi_t \tag{12}$$

Finally, from the definition of the CPI and the core consumption price level we have the following relation between the real price of Home goods and the real exchange rate:

$$0 = (1 - \alpha) pr_{H,t} + \alpha rer_t. \tag{13}$$

2.3 Aggregate Equilibrium

The market clearing condition for the Home goods is given by the following expression:

$$y_{H,t} = \frac{C_H}{Y_H} c_{H,t} + \left(1 - \frac{C_H}{Y_H}\right) c_{H,t}^* \tag{14}$$

where the ratio $\frac{C_H}{Y_H}$ corresponds to the steady state fraction of Home goods consumed by domestic households. This ratio is set to 0.58.

On the other hand, the net foreign asset position of the domestic economy evolves according to the following expression:

$$\begin{aligned} (1-\varrho)\,\beta b_t^* \quad = \quad & \beta i_t^* + +\beta\zeta_{\varphi,t} + b_{t-1}^* + c_{H,t-1}^* + pr_{H,t-1} + \chi\left(\Delta e_t - \pi_t\right) \\ & + \left(\frac{C_H^*}{\mathbf{B}} - \beta\right) c_{H,t}^* + \left(\frac{C_H^*}{\mathbf{B}} - \beta\right) pr_{H,t} \\ & - \frac{C_F}{\mathbf{B}} c_{F,t} - \frac{C_F}{\mathbf{B}} rer_t \end{aligned} \tag{15}$$

where $\mathbf{B} = \frac{\mathcal{E}B}{P_H}$ is the net asset position in steady-state expressed in terms of Home goods and C_H^* and C_F represent the steady state level of export and imports to GDP, respectively. In line with Medina and Soto (2005), we set C_H^* 41.2% and C_F to 39.2%.

2.4 Monetary Policy

To characterized the monetary policy we assume the central bank sets its policy interest rate according to a simple Taylor-type rule. In particular, the nominal interest rate[4] responds to deviations of CPI inflation from target and to deviation of output growth from trend. This rule also incorporates a reaction to past interest rate. This inertial component reflects the fact that monetary policy adjusts partially when new information becomes available. This rule takes the form:

$$i_t = \psi_i i_{t-1} + (1-\psi_i)\,\psi_\pi \pi_t + (1-\psi_i)\,\psi_y\left(y_t - y_{t-1}\right) + \epsilon_{i,t} \tag{16}$$

where ϵ_i represents a policy innovation unrelated to macroeconomic conditions reflected in inflation and output.

2.5 Exogenous Processes

We model foreign variables, y_t^*, π_t^* and i_t^*, as well as domestic technology shocks, a_{ht}, and consumer preference shocks, $\zeta_{c,t}$, as exogenous AR(1) processes. In particular:

$$y_t^* = \rho_{y^*} y_{t-1}^* + \epsilon_{y^*,t} \tag{17}$$

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \epsilon_{\pi^*,t} \tag{18}$$

[4] We define the rule in nominal terms, given the fact that the Chilean Central Bank has adopted as its main policy instrument the nominal interbank interest rate since July 2001.

$$i_t^* = \rho_{i^*} i_{t-1}^* + \epsilon_{i^*,t} \tag{19}$$

$$a_{h,t} = \rho_a a_{h,t-1} + \epsilon_{a,t} \tag{20}$$

$$\zeta_{c,t} = \rho_c \zeta_{c,t-1} + \epsilon_{c,t} \tag{21}$$

where the persistence coefficients, ρ_{y^*}, ρ_{π^*}, ρ_{i^*}, ρ_a and ρ_c, as well as the variance of the shocks, σ_{y^*}, σ_{π^*}, σ_{i^*}, σ_a and σ_c are going to be estimated. Now, in the case of monetary policy innovations, ϵ_i, we assume they are not persistent. As a consequence, only the variance of the shock, σ_i, has to be estimated [5].

Interest rate spread shocks, $\zeta_{\widetilde{i},t}$ and country risk premium shocks, $\zeta_{\varphi,t}$, also follow AR(1) processes:

$$\zeta_{\widetilde{i},t} = \rho_{\widetilde{i}} \zeta_{\widetilde{i},t-1} + \epsilon_{\widetilde{i},t} \tag{22}$$

$$\zeta_{\varphi,t} = \rho_\varphi \zeta_{\varphi,t-1} + \epsilon_{\varphi,t} \tag{23}$$

where, as before, the variance of the shocks, $\sigma_{\epsilon_{\widetilde{i}}}$ and $\sigma_{\epsilon_{\varphi,t}}$ as well as the persistence coefficients are to be estimated.

3 Model Estimation

3.1 Empirical methodology

The model is estimated by using a Bayesian approach (see DeJong, Ingram, and Whiteman, 2000; Lubik and Schorfheide, 2005)[6]. The Bayesian approach is a system-based methodology that fits the DSGE model to a vector of time series. The estimation is based on the likelihood function generated by the solution of the log-linear version of the model. Prior distributions are used to incorporate additional information into the parameters' estimation.

We estimate the model developed in the previous section. Equations (1) through (30) form a linear rational expectation system that can be written in canonical form as

$$\Omega_0(\vartheta)\,\mathbf{z}_t = \Omega_1(\vartheta)\,\mathbf{z}_{t-1} + \Omega_2(\vartheta)\,\varepsilon_t + \Omega_3(\vartheta)\,\xi_t$$

[5]Despite the fact that this shock is not persistent, it can have a persistent impact on the policy rate given the smoothness coefficient in the Taylor rule.

[6]Fernández-Villaverde and Rubio-Ramírez (2004) and Lubik and Schorfheide (2005) discuss in depth the advantages of this approach to estimate DSGE models.

where $\mathbf{z}_t = \{c_t,\, c_{F,t},\, c_{H,t},\, c^*_{H,t},\, i_t,\, \widetilde{i}_t,\, \pi_t,\, \pi_{H,t},\, \pi_{F,t},\, \Delta e_t,\, b^*_t,\, rer_t,\, pr_{H,t},\, pr_{F,t},\, wr_t,\, mrs_t,\, l_t,\, y_t,$ $y_{H,t},\, a_{H,t},\, y^*_t,\, \pi^*_t,\, i^*_t,\, \zeta_{c,t},\, \zeta_{c,t},\, \zeta_{\widetilde{i},t},\, \zeta_{\varphi,t}\}$ is a vector containing the model's variables expressed as log-deviations from their steady-state values, $\epsilon_t = \{\epsilon_{i^*,t},\, \epsilon_{y^*,t},\, \epsilon_{\pi^*,t},\, \epsilon_{c,t},\, \epsilon_{a,t},\, \epsilon_{i,t},\, \epsilon_{\widetilde{i},t}, \epsilon_{\varphi,t}\}$ is a vector containing white noise innovations to the structural shocks of the model, and ξ_t is a vector containing rational expectation forecast errors. Matrices Ω_i are non-linear functions of the structural parameters contained in vector ϑ. The solution to this system can be expressed as follows

$$\mathbf{z}_t = \Omega_z(\vartheta)\,\mathbf{z}_{t-1} + \Omega_\varepsilon(\vartheta)\,\varepsilon_t \tag{24}$$

where Ω_z and Ω_ε are functions of the structural parameters.

Let $\mathbf{y}_t$ be a vector of observable variables. This vector is related to the variables in the model through a measurement equation:

$$\mathbf{y}_t = H\mathbf{z}_t + \mathbf{e}_t \tag{25}$$

where H is a matrix that selects elements from $\mathbf{z}_t$. In our case we assume that the vector of observable variables is given by $\mathbf{y}_t = \{dy_t,\, \pi_t,\, dc_t,\, i_t,\, i^*_t,\, y^*_t,\, \zeta_{\widetilde{i},t},\, \zeta_{\varphi,t}\}$. The rest of the variables are assumed to be non-observable. The $\mathbf{e}_t$ matrix contain measurement errors.

Equations (24) and (25) correspond to the state-space form representation of $\mathbf{y}_t$. If we assume that the white noise innovations are normally distributed, we can compute the conditional likelihood function for the structural parameters using the Kalman filter, $L(\vartheta \mid \mathcal{Y}^T)$, where $\mathcal{Y}^T = \{\mathbf{y}_1, ..., \mathbf{y}_T\}$. Let $\mathbf{p}(\vartheta)$ be a prior density on the structural parameters. We can use data on the observable variables $\mathcal{Y}^T$ to update the priors through the likelihood function. The joint posterior density of the parameters is computed using the Bayes theorem

$$\mathbf{p}\left(\vartheta \mid \mathcal{Y}^T\right) = \frac{L(\vartheta \mid \mathcal{Y}^T)\mathbf{p}(\vartheta)}{\int L(\vartheta \mid \mathcal{Y}^T)\mathbf{p}(\vartheta)\, d\vartheta} \tag{26}$$

In order to derive the posterior distribution of the coefficients, we proceed in two steps. First, we find the posterior mode, which is the most likely point in the posterior distribution, and computed the Hessian at the mode. In doing so, we use a standard optimization routine.[7] In this case the likelihood function is computed by first solving the model and then using the Kalman filter. Second, we implement the Metropolis-Hastings algorithm to construct the posterior (for more details, see Appendix B in Medina and Soto (2005)).

One of the advantages of the Bayesian approach is that it can cope with potential model misspecification and possible lack of identification of the parameters of interest. For example, if in a misspecified model the likelihood function peaks at a value that is at odds with the prior information of any given parameter, the posterior probability will be low. Therefore, the prior

[7] The `csminwel` command in Matlab.

density allows to weight information about different parameters according to its reliability. On the other hand, lack of identification may lead to a likelihood function that is flat for some parameter values. Hence, based on the likelihood function alone, it may not be possible to identify some parameters of interest. In this case, a proper prior can introduce curvature into the objective function, the posterior distribution, making it possible to identify the values of different parameters (Lubik and Shorfheide, 2005).

The parameter vector to be estimated is $\vartheta = \{\sigma_c, h, \phi_L, \chi_L, \phi_H, \chi_H, \phi_F, \chi_F, \psi_i, \psi_\pi, \psi_y, \eta, \eta^*, \gamma, \rho_a, \rho_{y^*}, \rho_{\pi^*}, \rho_c, \rho_{\tilde{i}}, \rho_\varphi, \sigma_a, \sigma_i, \sigma_c, \sigma_{y^*}, \sigma_{i^*}, \sigma_{\pi^*}, \sigma_{\epsilon_{\tilde{i}}}, \sigma_{\epsilon_\varphi}\}$. The other parameters of the model include the steady state value of some long-run relationships previously discussed and some other calibrated coefficients. In particular, we set the discount factor, β, to 0.99 (annual basis). The elasticity of substitution among labor varieties, ϵ_L, is set to 11. This value is in the range of values used in previous studies [8]. The coefficient, the elasticity of labor supply, σ_L, is set to 1. On the other hand, which is the value obtained by Medina and Soto (2005). Finally, is the elasticity of the risk premium to the net foreign asset position, ϱ is set tom 0.001.

3.2 Data

To estimate the model we use Chilean quarterly data for the period from 2001Q2 to 2010Q4. The eight observable variables are: quarterly output growth, dy_t, private consumption growth, dc_t, nominal policy rate, i_t, core inflation, π_t, foreign nominal interest, i^*, foreign output, y^*, domestic interest rate spread, ζ_i and Chiles country risk premium index, ζ_φ. National data are from National Accounts series published by the Chilean Central Bank. The domestic spread is the difference between the lending rate and the policy rate, where the lending rate is an average between the short-term market rate (30 to 90 days) and the medium-term lending rate (90 to 360 days) . The foreign interest rate is the nominal 90 days LIBO rate in US$. Foreign output is a weighted average of the GDP of Chiles main trading partners. Finally, the country risk premium is the EMBI index for Chile. In order to work with stationary series we demean all variables. Figure (1) shows the evolution of the variables. Clearly, during the financial crisis of 2008-2009, output and consumption reacted strongly in an environment of increasing domestic spread and country risk premium.

3.3 Prior distributions

Priors' density functions reflect our beliefs about parameter values. Setting a relatively high standard deviation for a density function implies that our prior for the corresponding parameter is more diffuse.

[8]See Christiano *et al.* (2005), Adolfson *et al.* (2007), Brubakk *et al.* (2005) and Jacquinot *et al.* (2005)

In general, we choose priors based on evidence from previous studies for Chile (Medina and Soto (2005)). When the evidence is weak or nonexistent, we impose more diffuse priors. For σ_c we assume an inverse gamma distribution with mean 1.0 and three degrees of freedom. In the case of h we assume a beta distribution with with mean 0.8 and a standard deviation of 0.1.

The policy rate persistence, ψ_i is assumed to follow a beta distribution with a mean of 0.880. The policy response to inflation and output growth, the parameters ψ_π and ψ_π, are assumed to follow a gamma distribution with mean of 1.8 an 0.42 respectively in line with the estimated policy-rule coefficients in previous studies for Chile.[9].

The coefficients associated to price stickiness and wage stickiness, ϕ_L, ϕ_H and ϕ_F and the wage persistence coefficient, χ_L, are assumed to follow a beta distribution with a mean of 0.7 and a standard deviation of 0.2. The coefficients of domestic and foreign price indexation, χ_H, and ,χ_H, are assumed to follow a beta distribution with a mean of 0.5 and a standard deviation of 0.2. The coefficients η and η_* are assumed to follow an inverse gamma distribution with four degrees of freedom, and a mean of 0.5. The γ coefficient is assumed to follow a beta distribution with mean of 0.8 and a standard deviation of 0.1.

The autoregressive parameters of the stochastic shocks, have beta distributions. This means that their value should lie in the (0,1) interval range. We do not impose tight priors on these distributions, so shocks can be either persistent or non-persistent. In particular, for all parameters we set the prior mean at 0.7 and the standard deviation at 0.2.

The variances of the shocks are assumed to be distributed as an inverse gamma distribution with two or four degrees of freedom. The shape of this distribution implies a rather diffuse prior, i.e., we do not have strong prior information on those coefficients. In any case, the means of the distributions are set based on previous single equation estimations and on trials with weak priors.

4 Results

After computing the posterior mode we construct the posterior distribution with the Metropolis-Hastings algorithm[10]. In Table (1) we present both, the posterior mean and the standard deviation of the estimated distribution of the parameters.

We find a larger infratemporal elasticity of substitution, σ_c, and a high degree of habit formation in consumption (h nearly 0.9) than in Medina and Soto (2005). In terms of the the degree of wage stickiness, ϕ_L, and wage inertia, χ_L, we found smaller values than the ones

[9]See Schmidt-Hebbel and Tapia (2002) and Caputo (2005).

[10]We implement this algorithm with two two chains of 50.000 draws with a 50% initial burn-in phase. The acceptance rates were about 30%. We do not present the plots of the posterior distributions, but they are available upon request.)

found in previous studies. In particular, the posterior mean of ϕ_L is 0.58, which is coherent with wages that are kept fixed for nearly three quarters. The degree of domestic price stickiness, (ϕ_H), is 0.5 implying that domestic prices are kept fixed for two quarters. On the other hand, the domestic inflation indexation coefficient, χ_H, is 0.46. Those values are coherent with the ones found in previous studies for Chile. The degree of import price stickiness and inertia is very similar to that found for domestic prices.

The policy rule coefficients, ψ_i, ψ_π and ψ_y have posterior mean values that are very similar to the prior mean ones. This implies that those coefficients are not very well identified. The estimated elasticity of substitution between Home and Foreign goods in the consumption basket of domestic households, η, is 0.3. In turn, the estimated value for demand elasticity of Home goods abroad, η^*, is 0.8. These values are somehow below the corresponding ones estimated previously for Chile, and for the euro area in Adolfson *et al.* (2007).

All exogenous shocks present a high degree of inertia. In the case of domestic spread shocks and country risk premiums shocks, the AR(1) coefficient is 0.93 and 0.8 respectively. In this case, the estimated standard deviation of spread shock and country risk premium shocks is close to 0.2 (see Table (2)).

4.1 Impulse Response Analysis and Historical Decomposition

Overall, the estimated coefficients are, in a broad sense, coherent with the ones found in previous studies. Now, to see how the variables in the model react to spread and to country risk premium shocks, we compute the impulse response functions in each case. A spread shock, shown in Figure (2), increases the market interest rate, reducing consumption and output. As a consequence, inflation also declines. In this case, and despite the decline in the policy rate, the exchange rate tends to decline, both in real and nominal terms [11]. As expected the market policy rate remains above its steady state level for various quarters.

A country risk premium shock, on the other hand, induces an increase in the nominal and real exchange rate (Figure (3). This generates an increase in inflation and an incipient increase in output (due to the expenditure switching effect). The monetary authority increases the nominal interest rate, which reduces output.

Now in both cases analyzed before, output declines, but the movements in the other variables, namely inflation and the nominal and real exchange rate, go in opposite directions. This difference is and advantage because it improves the ability to identify, from the data, whether

[11] This result is determined, importantly, by the way in which monetary policy is specified in the model. In particular, the Taylor rule in (16) reacts to *changes* in the output level. If the rule is modified to react to the output *level*, the policy rate (and the real ex-ante real rate) would have declined much more aggressively, inducing a real and nominal devaluation, an increase in the exchange rate (nominal and real) and an increase in inflation.

the observed reduction in output is due to a spread shock or to a country risk premium shock.

To make a formal assessment of the contribution of each structural shock to the output cycle, we present the historical decomposition of the GDP growth [12] in Figure (4). As expected, the decomposition attributes part of the fall in growth, during 2008 and 2009, to adverse foreign output, domestic spreads and country risk premium shocks. In particular, in 2009.Q2, 20% of the output decline is explained by the spread shock, 19% by foreign output contraction and 6% by the increase in the country risk premium indicators. Overall, 45% of the output decline can be attributed to these three shocks. The rest of the decline is explained by foreign inflation shocks (30%), productivity shocks (10%) and consumption preference shocks (7%).

4.2 Alternative Scenario: Persistent and non Persistent Components of Shocks

The persistence of the shocks determines the extend to which they are propagated to the rest of the economy. Although we obtain relatively high persistence coefficients for the spread and country risk premium shocks, it is possible that this persistence may have changed. In particular, a recursive regression for the ρ_R coefficient shows that its value has increased over time. As shown in Figure 5, after the collapse of Lehman Brothers, the persistence of the short-term interest rate spread (based on the 30 to 90 days lending rate) increased substantially from 0.7 to 0.9. The reason for this increase may be related to the global perception that tighter liquidity conditions were going to last longer after the Lehman collapse. A similar behavior can be observed for the persistence in country risk premiums shocks. The medium-term spread (based on the 90 to 360 days lending rate) did not experience a significant increased during that time, although it has been increasing since 2005.

Given the above evidence, we introduce an alternative way of modelling the behavior of these shocks. In particular, we assume that they are going to be determined by two components, one with a low degree of persistence (calibrated to 10%) and the other with a higher degree of persistence (calibrated to 95%). In particular, interest rate spread shocks, $\zeta_{\tilde{i},t}$ depend on a non persistent component, $\zeta^1_{\tilde{i},t}$, and a persistent one, $\zeta^2_{\tilde{i},t}$ in the following way:

$$\zeta_{\tilde{i},t} = \zeta^1_{\tilde{i},t} + \zeta^2_{\tilde{i},t} \tag{27}$$

where,

$$\zeta^1_{\tilde{i},t} = 0.1\zeta^1_{\tilde{i},t-1} + \epsilon^1_{\tilde{i},t} \tag{28}$$

$$\zeta^2_{\tilde{i},t} = 0.95\zeta^2_{\tilde{i},t-1} + \epsilon^2_{\tilde{i},t} \tag{29}$$

[12] GDP growth is the cumulative growth rate over the las four quarters.

The variances of the shocks, $\sigma_{\epsilon_i^1}$ and $\sigma_{\epsilon_i^2}$, are going to be estimated.

Analogously, the country risk premium shock, is going to be determined by a non persistent component, $\zeta^1_{\varphi,t}$, and a persistent one, $\zeta^2_{\varphi,t}$:

$$\zeta_{\varphi,t} = \zeta^1_{\varphi,t} + \zeta^2_{\varphi,t} \tag{30}$$

where

$$\zeta^1_{\varphi,t} = 0.1\zeta^1_{\varphi,t-1} + \epsilon^1_{\varphi,t} \tag{31}$$

$$\zeta^2_{\varphi,t} = 0.95\zeta^2_{\varphi,t-1} + \epsilon^2_{\varphi,t} \tag{32}$$

As before, the variances of the shocks, $\sigma_{\epsilon^1_\varphi}$ and $\sigma_{\epsilon^2_{\varphi,t}}$ are going to be estimated.

Once we introduce this alternative modelling approach, we reestimate the model using the same set of observable as before. We also maintain the same assumptions regarding the prior mean and prior distribution of parameters and shocks.

In Table (3) and (4) we present both, the posterior mean and the standard deviation of estimated parameters and shocks [13]. Results, in general, did not change from the previous scenario. However, in the case of the price elasticity of foreign demand, the η^* coefficient, it increases from 0.77 to 1.22. The variance of the preference shock, σ_c, on the other hand, declines from 1.22 to 0.58. This latter result, as we will see, can be explained by the fact that part of the output contraction now is attributed, in greater proportion, to country risk premium shocks.

Results, in terms of the IRF, show that a higher degree of persistence in spread and country risk premium shocks tend to amplify the effects of such innovations. For instance, a persistent spread shock (Figure (6)) of 24 basis points reduces output twice as much than in the baseline scenario. As expected a non persistent spread shock has a negligible effect on output. On the other hand, a persistent country risk premium shock induces a contraction in output which is much more severe than the one we obtained in the baseline case (Figure (7)).

The estimated shock, presented in Figure (8), show that the persistent spread (ϵ^2_i) and country premium (ϵ^2_φ) shocks reached their higher level at the end of 2009. In this context, the shock identification strategy enables us to isolate certain episodes in which those shocks were more persistent.

The historical decomposition of GDP growth attributes, again, important part of the fall in output during 2008 and 2009 to adverse foreign output, domestic spreads and country risk premium shocks. In this case, however, the relative importance of foreign country risk premium shocks increases from 6% to 25% in 2009.Q2. The contribution of foreign output and domestic

[13] As in the baseline scenario, we implement this algorithm with two two chains of 50.000 draws with a 50% initial burn-in phase. The acceptance rates was about 34%.

spread does not change significantly. The contribution of preference shocks, in this alternative specification, is now negligible. This can be associated to an increased importance of country risk premium shocks, that now are able to explain a higher proportion of output fluctuations.

Overall, we conclude that and important fraction of the output decline in 2008 and 2009 can be attributed to shocks that were not originated in Chile. In particular, in 2009.Q2 60% of the output decline can be attributed to foreign output, spread and country risk premium shocks.

4.3 Mitigating the Effects of Adverse Shocks: Counterfactual Taylor Rules

To see the extent to which alternative ways of conducting monetary policy may have alleviated the adverse effect of foreign shock, we analyze the implications of alternative Taylor rules. In particular, given the sequence of estimated shocks in the previous subsection, we compute the counterfactual evolution of output, inflation, exchange rate (nominal and real), the policy rate and the market rate under alternative monetary policy rules.

In the first case, we consider a scenario in which the Taylor rule is augmented in order to respond systematically to spread shocks, $\epsilon_{\widetilde{i},t}$. This type of rule has been advocated by Taylor (2008) and it reflects the way in which some central banks (Swiss National Bank) actually behave. The modified rule we consider can be expressed as:

$$i_t = \psi_i i_{t-1} + (1-\psi_i)\,\psi_\pi \pi_t + (1-\psi_i)\,\psi_y\,(y_t - y_{t-1}) + \psi_i \epsilon_{\widetilde{i},t} + \epsilon_{i,t}$$

this rule is used to recompute the evolution of all endogenous variables, *given* the estimated parameters in Table (3) and the sequence of shocks presented in Figure (8) and (9). The results, shown in Figure (11), indicate that output would have declined by less during 2008 and 2009 under this alternative rule. In particular, output growth would have been 2% higher, on average, during that period[14]. Inflation, on the other hand, would have been 1% higher in the same period, as well as the exchange rate. The counterfactual nominal policy rate, would have been also higher. This, however, does not imply that the counterfactual policy rate is more hawkish. On the contrary, the real interest rate would have declined, mitigating the adverse effects of foreign shocks during 2008 and 2009. Hence, a higher nominal policy rate is just the consequence of higher, and credible, level of inflation induced by this policy rule.

In a second exercise, we consider a scenario in which the policy reaction to output growth, ψ_y, is multiplied by four. Again, we take the structural coefficients and exogenous shocks as given. In this case, the results are quite similar to the previous case: output would have declined by less and inflation would have been higher. The policy rate would have increased

[14]The annual rate of growth is normalized to zero in 2008.Q2

initially (as a consequence of a higher inflation level), but then it would have declined by 50 basis points compared to the base scenario.

The conclusion of these exercises is that in both cases monetary policy would have been more efficient at avoiding the contraction in activity. At the same time, the fall in inflation would have been less and the equilibrium nominal interest rate would have reached higher levels. This implies that the risks of reaching the zero lower bound for the interest rate, would have been lower under either of the alternative rules.

Finally, when we consider an alternative set of observables our main results remain unchanged. In particular, if the foreign interest rate, which is observable, is replaced by another series, the RER, the parameters as well as the history decomposition of shocks does not change significantly. In this case, an important element behind the output contraction during the crisis is attributed, as before, to foreign output, spread and country risk premium shocks (see Figure 13)

5 Conclusions

This paper analyzes the consequence of the global financial crisis of 2008 and 2009 on the Chilean economy. In doing so, we estimate a small open economy DSGE model extended to incorporate financial frictions, namely domestic spread and country risk premium shocks.

Our results indicate that foreign shocks (spread, county risk premium and foreign output shocks) played a major role in explaining the downturn in activity in Chile in 2008 and 2009. In particular, they account for 40 to 60% of the predicted decline in output in that period. Other shocks, such as demand or productivity shocks did not have a relevant impact on the Chilean business cycle in that period .

Using the estimated model and the inferred shocks we analyzed the extend to which alternative policy rules may have mitigated the impact of adverse foreign shocks. In particular, we consider two alternative rules: one that is more aggressive responding to output fluctuations, and another that reacts to financial market innovations. The conclusion of these exercises is that, in both cases, monetary policy would have been more efficient at avoiding the contraction in activity and the decline in inflation. As a result, this type of rules reduces also the risk of reaching the zero lower bound for the interest rate.

References

[1] Adolfson, M., S. Laseén, J. Lindé and M. Villani (2007), "Bayesian Estimation of an Open Economy DSGE Model with Incomplete Pass-Through," *of International Economics* 72(2), pp.481-511.

[2] Blanchard, O. and J. Gali (2005) "Real Wages Rigidity and the New Keynesian Model" *Journal of Money, Credit, and Banking* 39(S1), pp. 35-66

[3] Brubakk, L. T., A. Husebø, S. McCaw, D. Muir, B. Naug, K. Olsen, Ø. Røisland, T. Sveen and B. R. Wilhelmsen (2005), "Finding Nemo: From the Global Economy Model (GEM) to a National Core Model," Mimeo, Norges Bank.

[4] Calvo, G. (1983), "Staggered prices in Utility-maximizing Framework" *Journal of Monetary Economics* 12: 383-98.

[5] Caputo, R. (2005), "Exchange Rate and Monetary Policy Objectives in Small Open Economies," in Driver, Sinclair and Thoenissen (eds), *Exchange Rates and Capital Flows.* Routledge.

[6] Christiano, L., M. Eichenbaum and C. Evans (2005), "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy," *Journal of Political Economy* 113: 1-45.

[7] Cúrdia, V and M.Woodford (2010), "Credit Frictions and Monetary Policy," *Journal of Money, Credit and Banking* 42(S1):3-35.

[8] DeJong, D.N., B. Ingram and C. Whiteman (2000), "A Bayesian Approach to Dynamics Macroeconomics" *Journal of Econometrics* 98: 203-23.

[9] Erceg, Ch., D.W. Henderson and A. Levin (2000), "Optimal monetary policy with staggered wage and price contracts" *Journal of Monetary Economics* 46(2): 281-313.

[10] Fernandez-Villaverde and J. Rubio-Ramirez (2004), "Comparing Dynamic Equilibrium Economies to Data: A Bayesian Approach" *Journal of Econometrics* 123: 153-87.

[11] Gali, J. and T.Monacelli (2005), "Monetary Policy and Exchange Rate Volatility in a Small Open Economy" *Review of Economic Studies* 72(3): 707-734.

[12] Gerali, A., S. Neri, L.Sessa and F.Signoretti (2010), "Credit and Banking in a DSGE Model of the Euro Area" *Journal of Money, Credit and Banking* 42(S1): 107-141.

[13] Jacquinot, P., R. Mestre and M. Spitzer (2005), "An Open-Economy DSGE Model of the Euro Area," Mimeo, European Central Bank.

[14] Lubik,T. and F. Shorfheide (2005) “A Bayesian Look at New Open Economy Macroeconomics,” NBER Macroeconomics Annual.

[15] Medina, J.P. and C.Soto (2005), “Oil Shocks and Monetary Policy in an Estimated DSGE Model for a Small Open Economy Policy,” Central Bank of Chile, *Working Paper*, n353.

[16] Schmidt-Hebbel, K. and M. Tapia (2004), “Inflation Targeting in Chile,” *North American Journal of Economics and Finance* 13: 125-46.

[17] Taylor, J.(2008), “Monetary Policy and the State of the Economy,” Testimony before the Committee on Financial Services, US House of Representatives, February, 26th.

Table 1: Prior/Posterior Parameters Distribution (Baseline Scenario)

Name	Description	Prior Mean	st.dev/d.f.	Shape	Post.Mean	Post. st.dev.
σ_c	Elast. of Intertemp. Subst.	1	3	Invg	1.49	0.08
h	Habit Formation	0.8	0.1	Beta	0.84	0.02
ϕ_L	Calvo Probability Wages	0.7	0.2	Beta	0.58	0.16
χ_L	Wages Indexation	0.7	0.2	Beta	0.65	0.29
ϕ_H	Calvo Prob. of Dom. Inf.	0.7	0.2	Beta	0.49	0.16
χ_H	Dom. Price indexation	0.5	0.2	Beta	0.46	0.25
ψ_i	M.P. resp. to int. rate	0.88	0.1	Beta	0.80	0.03
ψ_π	M.P. resp. to inflation	1.8	0.1	Gamma	1.78	0.10
ψ_y	M.P. resp. to growth	0.42	0.1	Gamma	0.47	0.08
ϕ_F	Calvo Prob. to imp. goods	0.7	0.2	Beta	0.48	0.20
χ_F	Imp. goods Indexation	0.5	0.2	Beta	0.51	0.25
η	Elast. Subs. H/F	0.5	4	Invg	0.30	0.08
η_F	Price elast. For. Dem.	0.5	4	Invg	0.77	0.40
γ	Exports adjustment coeff.	0.8	0.1	Beta	0.76	0.09
ρ_a	AR. prod. shock	0.7	0.2	Beta	0.79	0.03
ρ_{y^*}	AR. foreing.output	0.7	0.2	Beta	0.87	0.07
ρ_{i^*}	AR.foreing.int.rate	0.7	0.2	Beta	0.88	0.03
ρ_{π^*}	AR.foreing.inflation	0.7	0.2	Beta	0.85	0.08
ρ_c	AR.preference shock	0.7	0.2	Beta	0.68	0.22
$\rho_{\tilde{i}}$	AR. spread	0.7	0.2	Beta	0.93	0.01
ρ_φ	AR. Country.risk	0.7	0.2	Beta	0.80	0.11

Table 2: Prior/Posterior Shocks Distribution (Baseline Scenario)

Name	Description	Prior Mean	st.dev/d.f.	Shape	Post. Mean	Post. st.dev.
σ_a	St. Dev. prod. shock	1.5	2	invg	1.19	0.61
σ_{y^*}	St. Dev. foreing.output	1	4	invg	0.65	0.07
σ_{i^*}	St. Dev. foreing.int.rate	0.5	4	invg	0.15	0.02
σ_{π^*}	St. Dev. foreing.inflation	0.5	4	invg	0.43	0.16
σ_i	St. Dev. M.P. shock	0.5	4	invg	0.20	0.02
σ_c	St. Dev. preference shock	0.5	2	invg	1.22	0.10
$\sigma_{\tilde{i}}$	St. Dev. spread	1	4	invg	0.19	0.02
σ_φ	St. Dev. Country. risk	1	4	invg	0.17	0.02

Table 3: Prior/Posterior Parameters Distribution (Alternative Scenario)

Name	Description	Prior Mean	st.dev/d.f	Shape	Post. Mean	Post. st.dev.
σ_c	Elast. of Intertemp. Subst.	1	3	Invg	1.64	0.12
h	Habit Formation	0.8	0.1	Beta	0.83	0.01
ϕ_L	Calvo Probability Wages	0.7	0.2	Beta	0.58	0.08
χ_L	Wages Indexation	0.7	0.2	Beta	0.61	0.25
ϕ_H	Calvo Prob. of Dom. Inf.	0.7	0.2	Beta	0.39	0.14
χ_H	Dom. Price indexation	0.5	0.2	Beta	0.41	0.24
ψ_i	M.P. resp. to int. rate	0.88	0.1	Beta	0.80	0.02
ψ_π	M.P. resp. to inflation	1.8	0.1	Gamma	1.75	0.09
ψ_y	M.P. resp. to growth	0.42	0.1	Gamma	0.42	0.08
ϕ_F	Calvo Prob. to imp. goods	0.7	0.2	Beta	0.49	0.12
χ_F	Imp. goods Indexation	0.5	0.2	Beta	0.55	0.24
η	Elast. Subs. H/F	0.5	4	Invg	0.34	0.07
η_F	Price elast. For. Dem.	0.5	4	Invg	1.21	0.21
γ	Exports adjustment coeff.	0.8	0.1	Beta	0.79	0.09
ρ_a	AR. prod. shock	0.7	0.2	Beta	0.87	0.01
ρ_{y^*}	AR. foreing.output	0.7	0.2	Beta	0.88	0.07
ρ_{i^*}	AR.foreing.int.rate	0.7	0.2	Beta	0.87	0.03
ρ_{π^*}	AR.foreing.inflation	0.7	0.2	Beta	0.76	0.05
ρ_c	AR.preference shock	0.7	0.2	Beta	0.72	0.19

Table 4: Prior/Posterior Shocks Distribution (Alternative Scenario)

Name	Description	Prior Mean	st.dev/d.f	Shape	Post. Mean	Post. st.dev.
σ_a	St. Dev. prod. shock	1.5	2	invg	1.36	0.55
σ_{y^*}	St. Dev. foreing.output	1	4	invg	0.67	0.07
σ_{i^*}	St. Dev. foreing.int.rate	0.5	4	invg	0.15	0.02
σ_{π^*}	St. Dev. foreing.inflation	0.5	4	invg	0.49	0.12
σ_i	St. Dev. M.P. shock	0.5	4	invg	0.21	0.02
σ_c	St. Dev. preference shock	0.5	2	invg	0.58	0.10
$\sigma_{\tilde{i}}^1$	St. Dev. spread1	1	4	invg	0.21	0.03
$\sigma_{\tilde{i}}^2$	St. Dev. spread2	1	4	invg	0.24	0.03
σ_φ^1	St. Dev. Country. risk1	1	4	invg	0.19	0.02
σ_φ^2	St. Dev. Country. risk2	1	4	invg	0.19	0.02

Figure 1: Observable Series: Quarterly Data 2001.Q2-2010.Q4

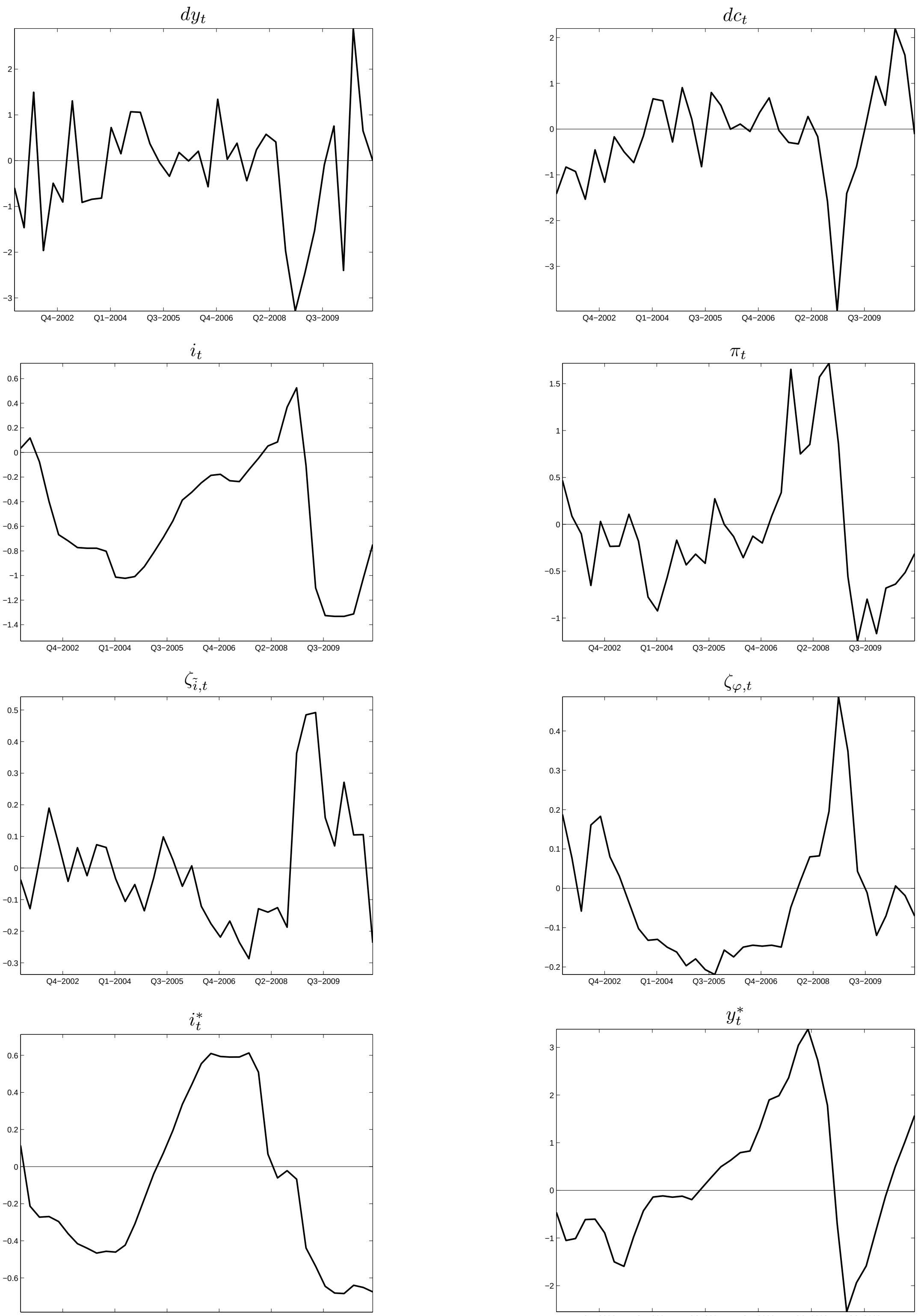

Figure 2: Responses to a Spread Shock (Baseline Case)

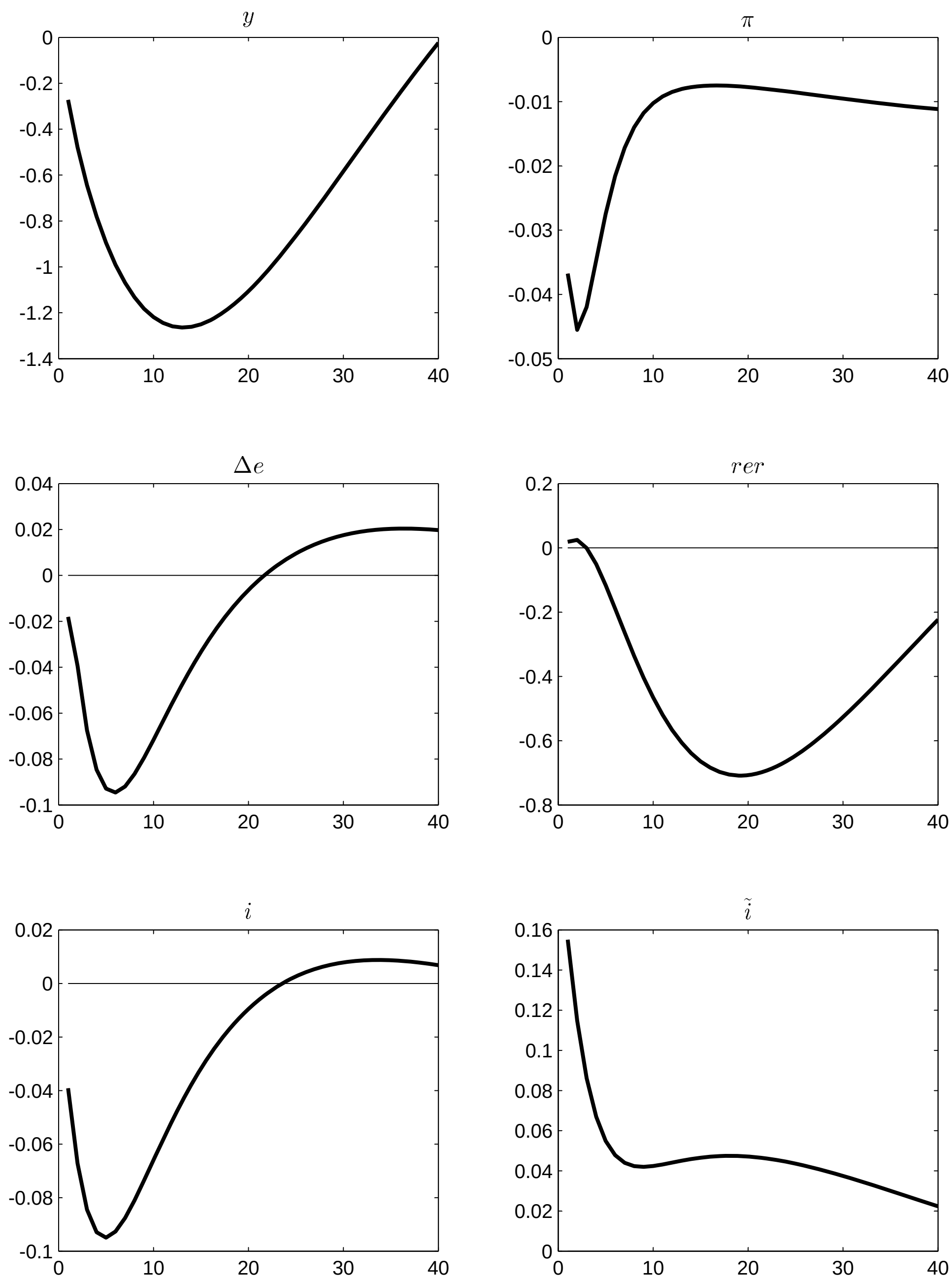

Figure 3: Responses to a Country Risk Premium Shock (Baseline Case)

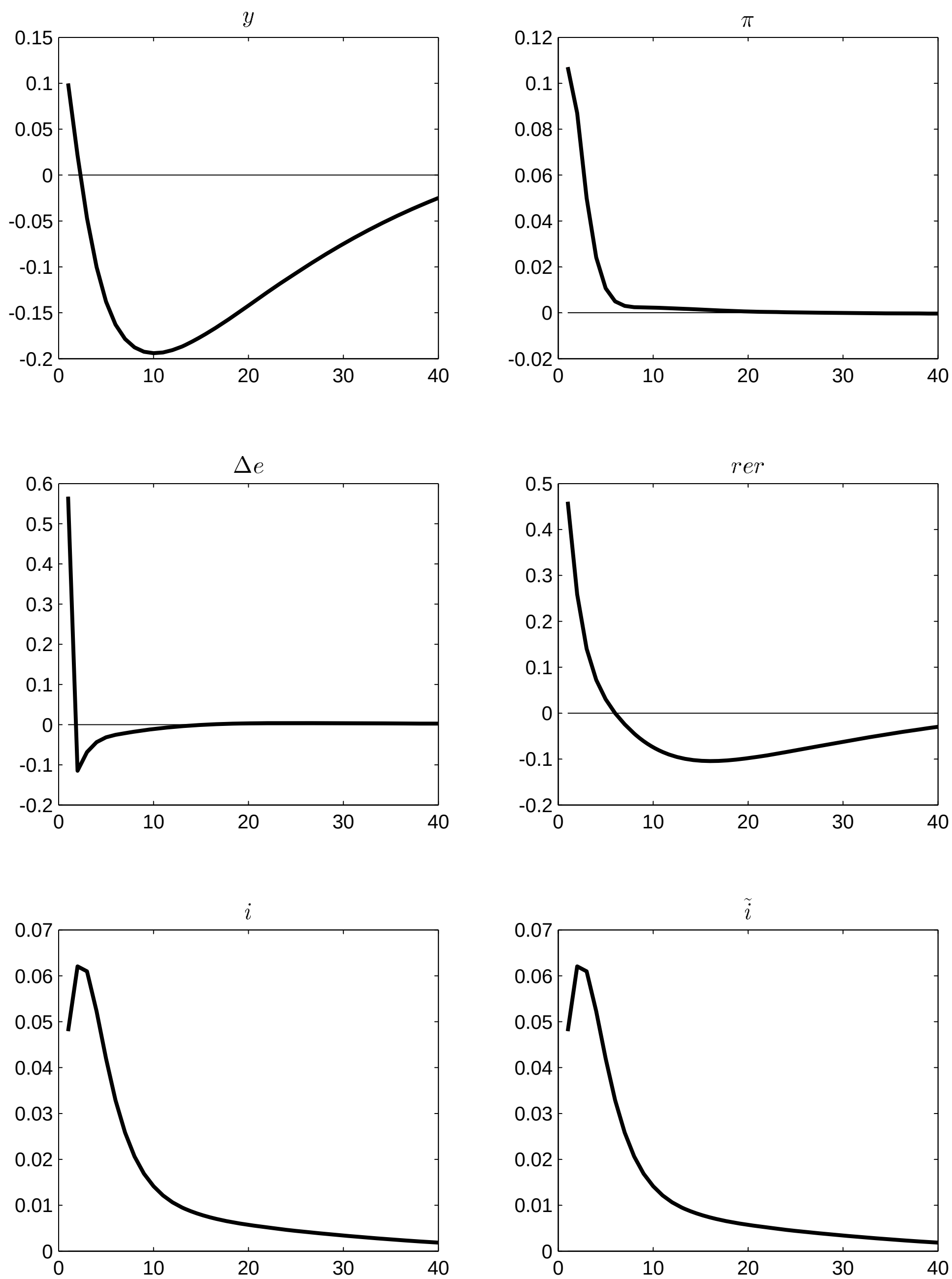

Figure 4: GDP Growth: Historical Decomposition (Baseline Case)

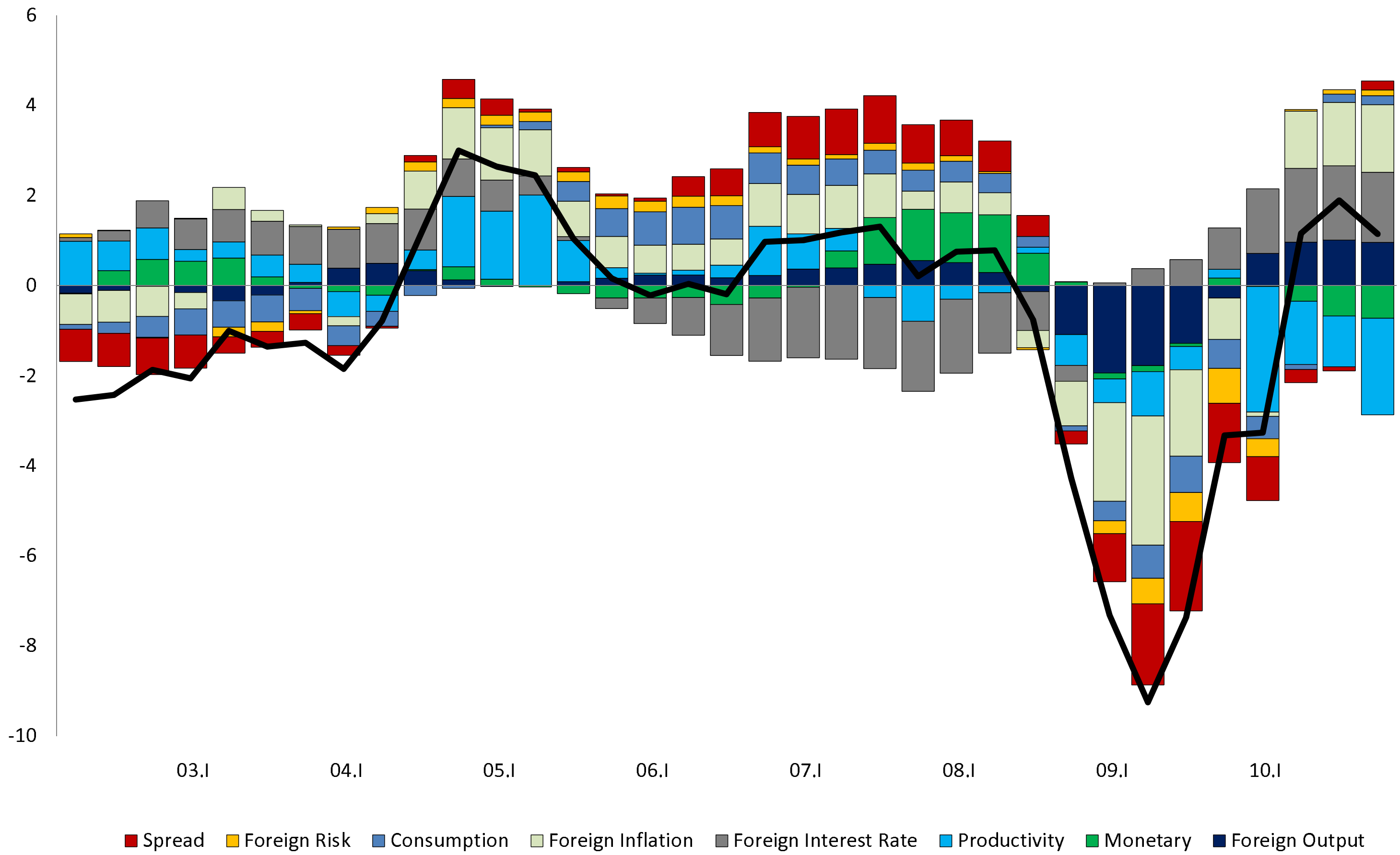

Figure 5: Evolution of Spread Persistence: Recursive Regressions

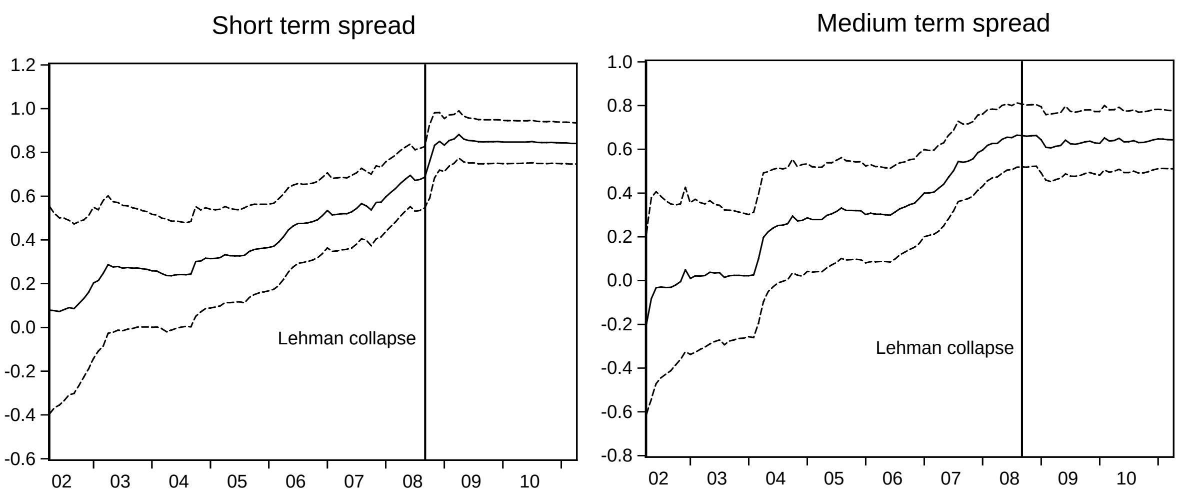

Figure 6: Responses to a Domestic Spread Shock

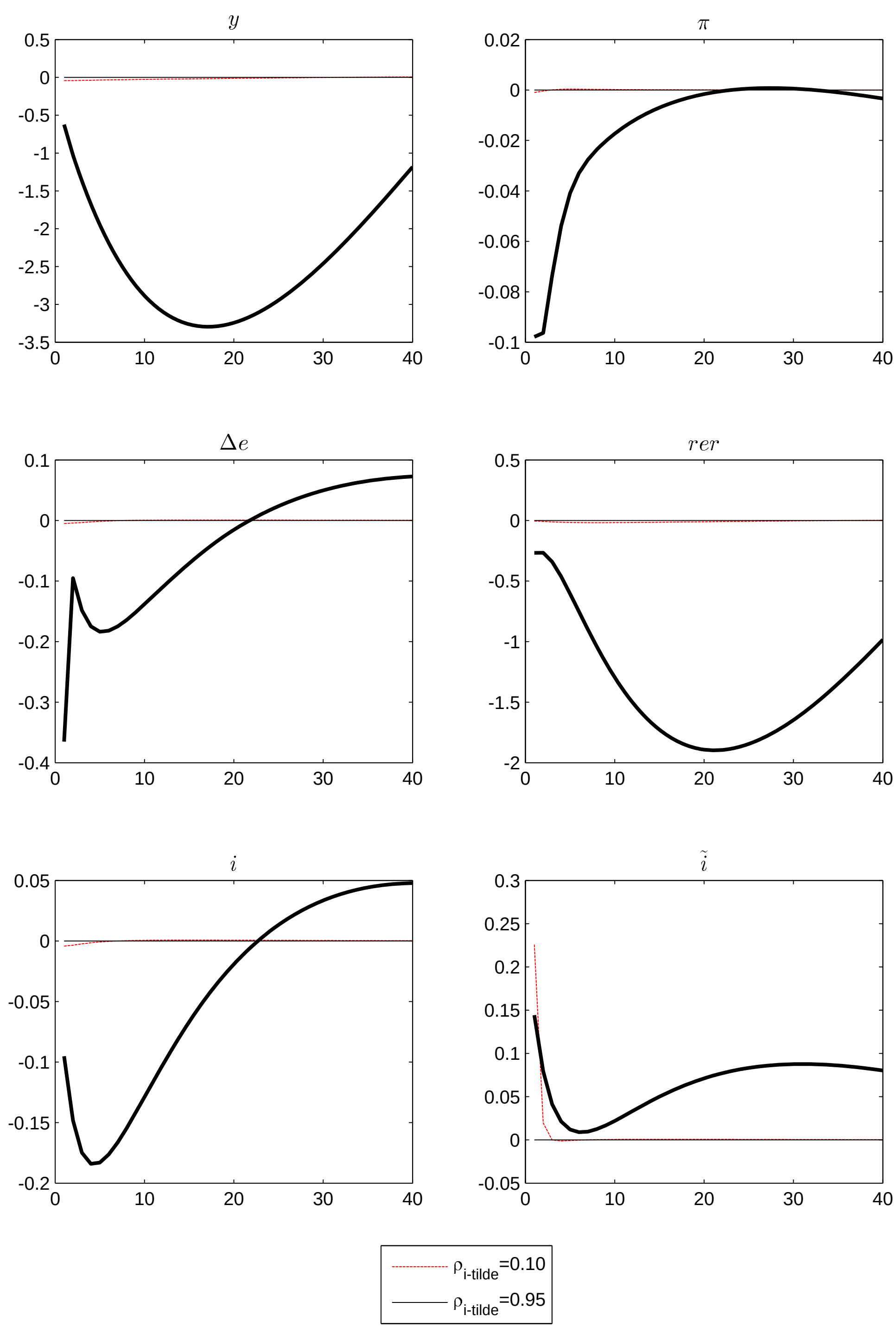

Figure 7: Responses to a Country Risk Premium Shock

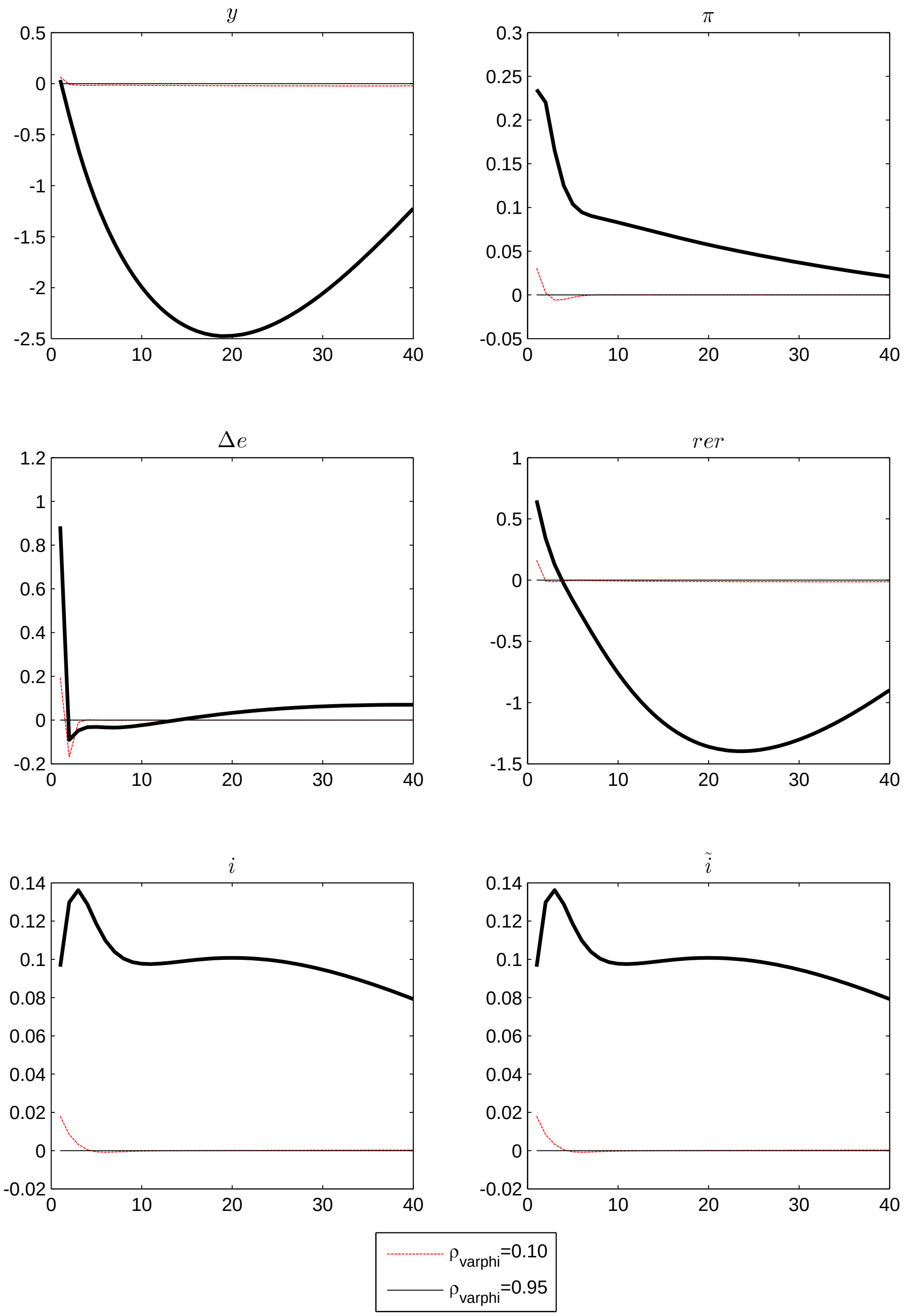

Figure 8: Smoothed Shocks I:2001.Q2-2010.Q4

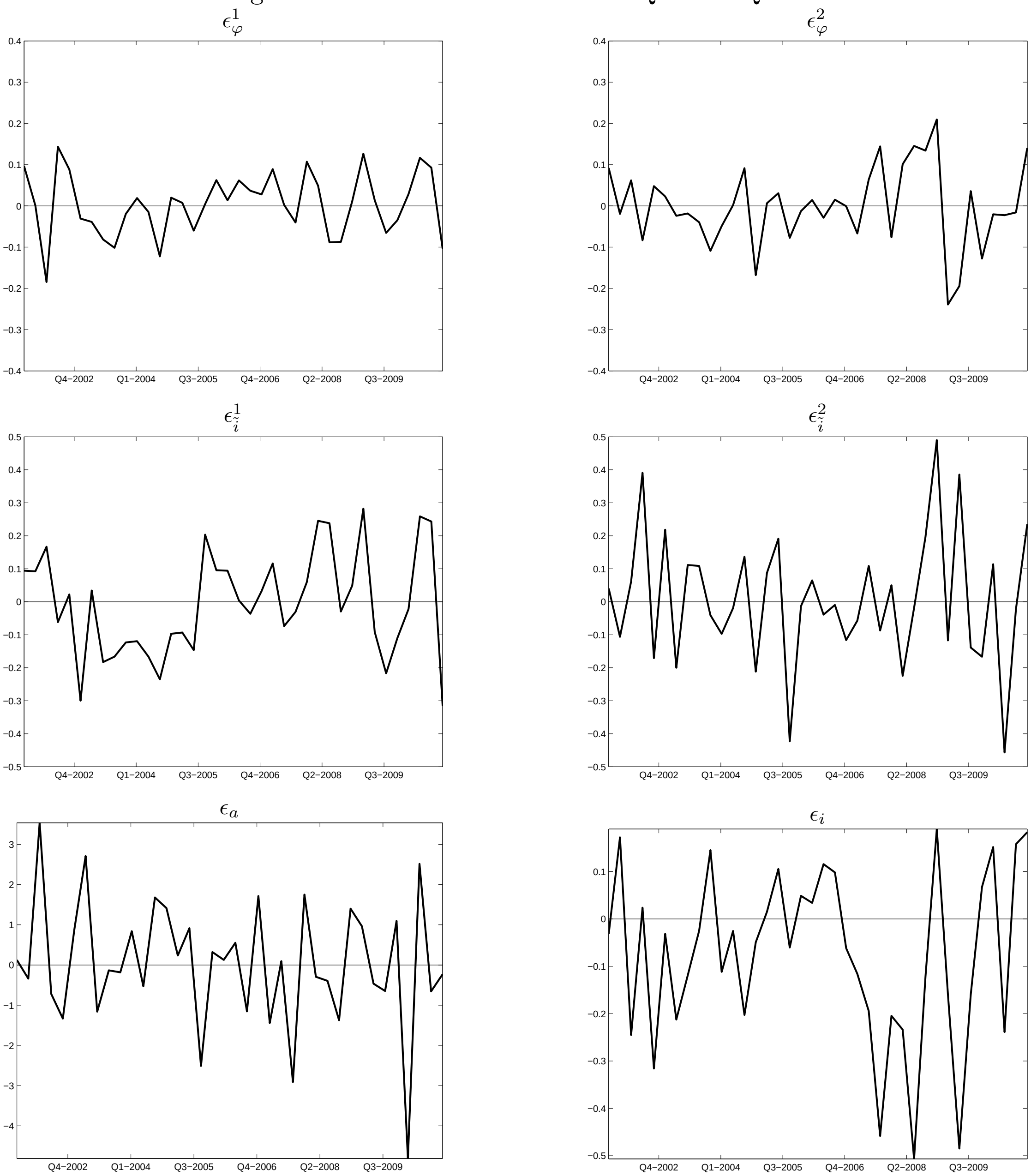

Figure 9: Smoothed Shocks II:2001.Q2-2010.Q4

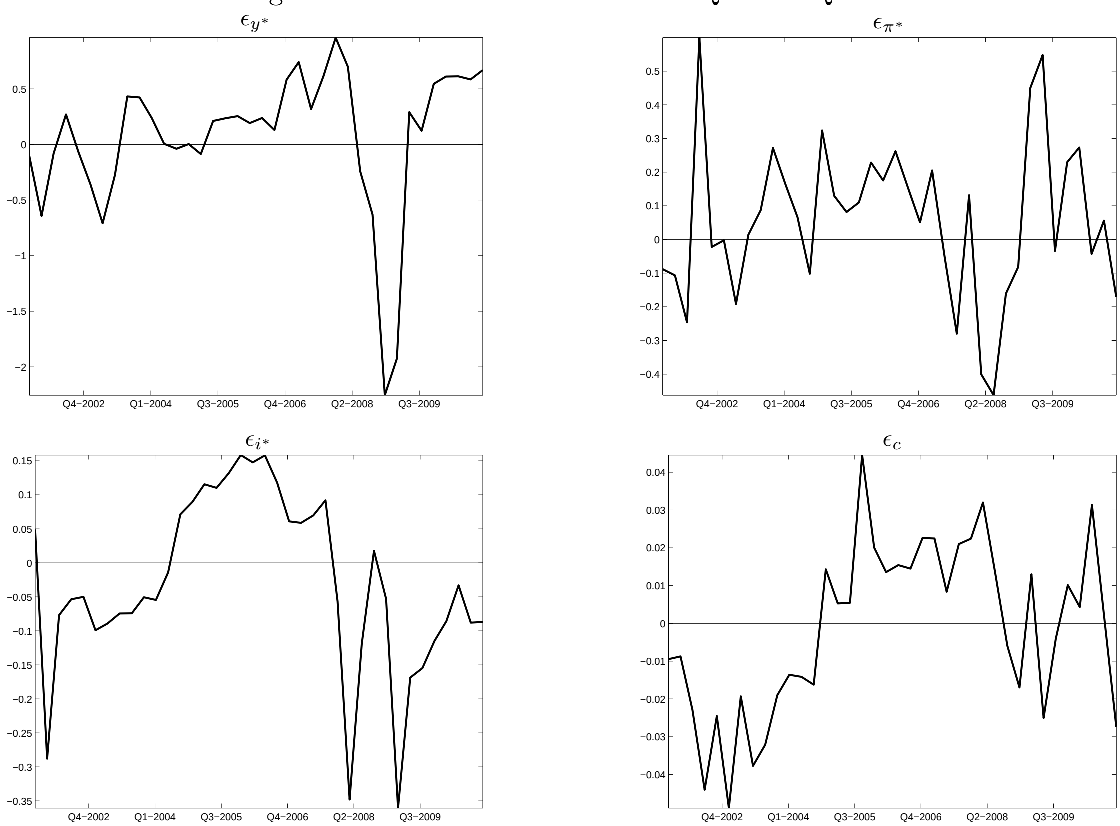

Figure 10: GDP Growth: Historical Decomposition

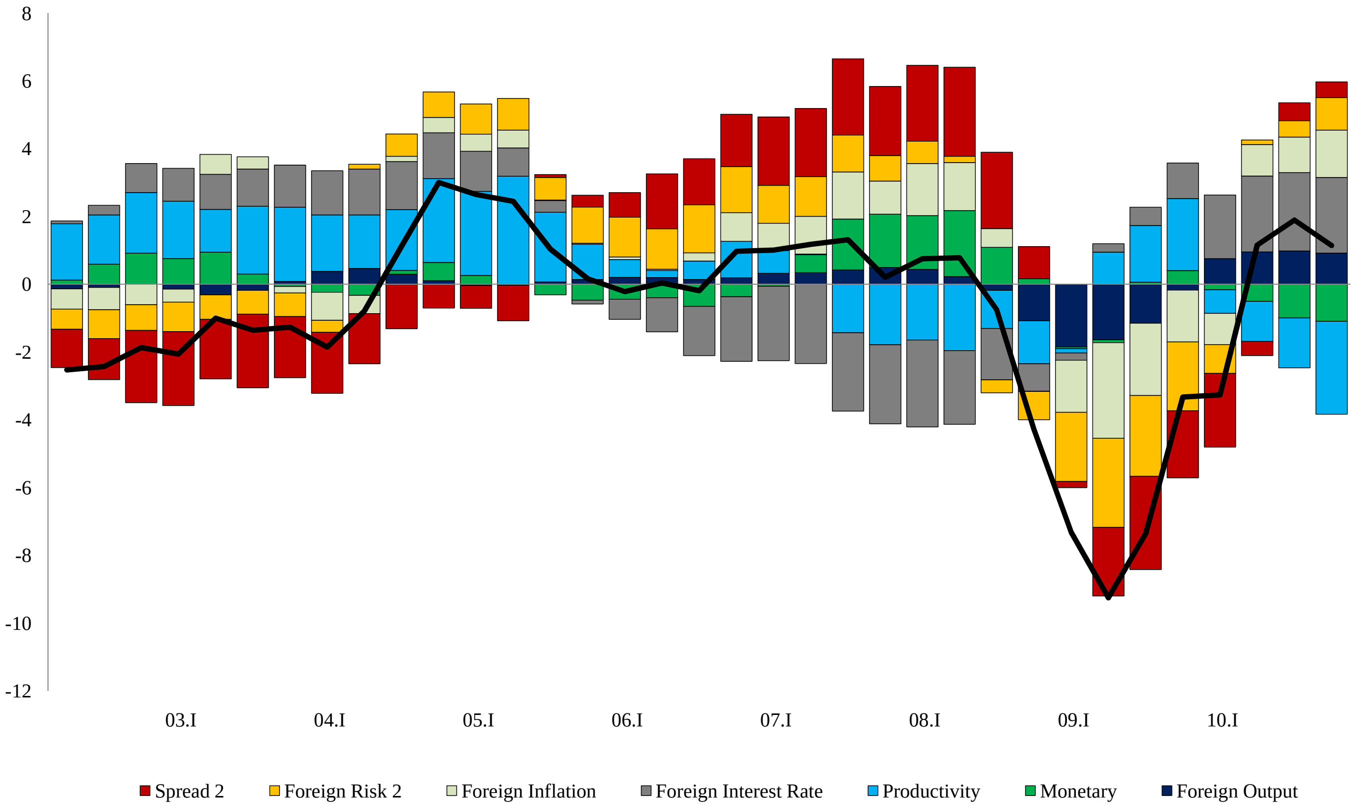

Figure 11: Counterfactual Scenario: Taylor Rule with response to $\zeta^{1}_{\tilde{i},t}$

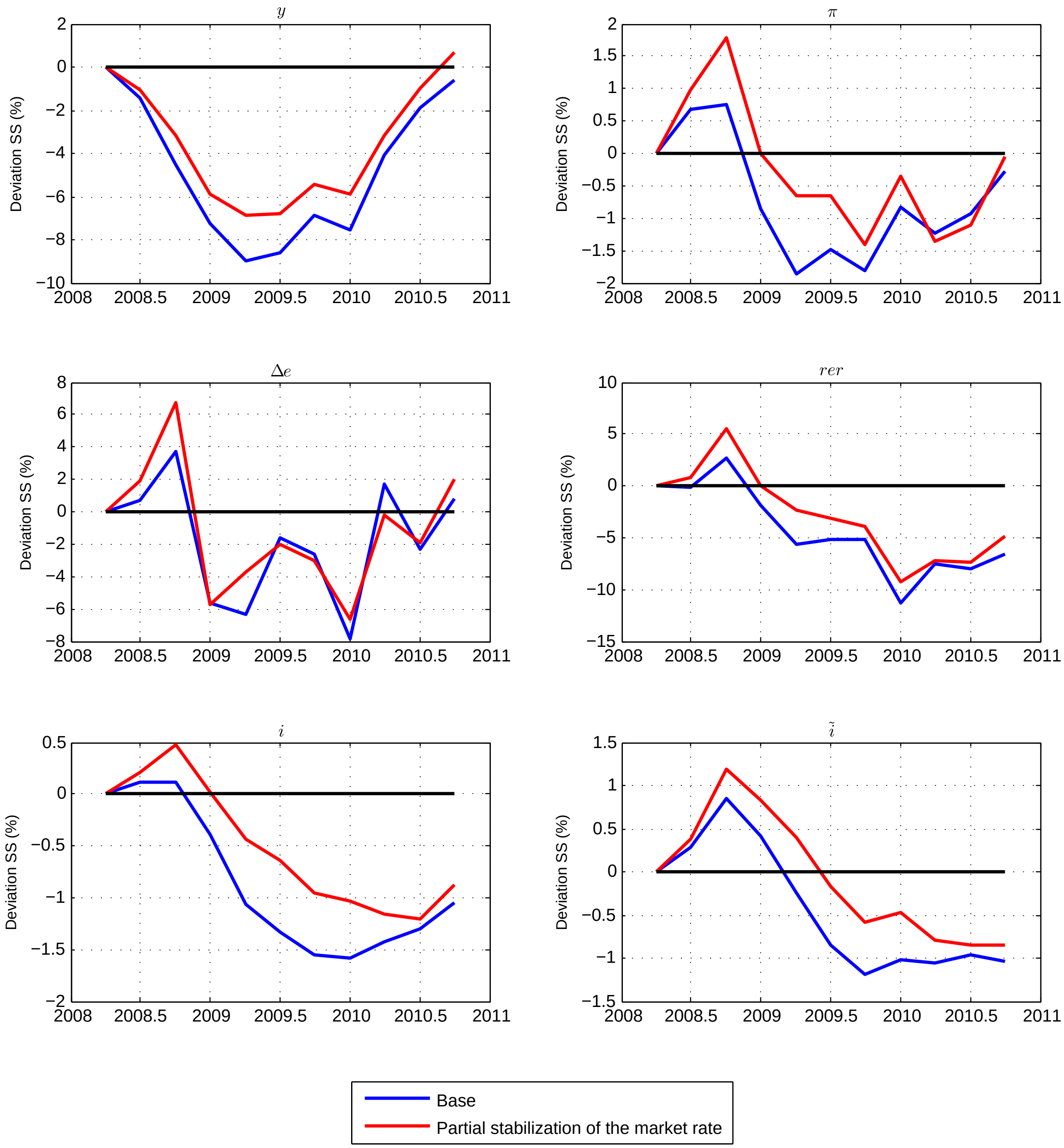

Figure 12: Counterfactual Scenario: Taylor Rule with larger ψ_y

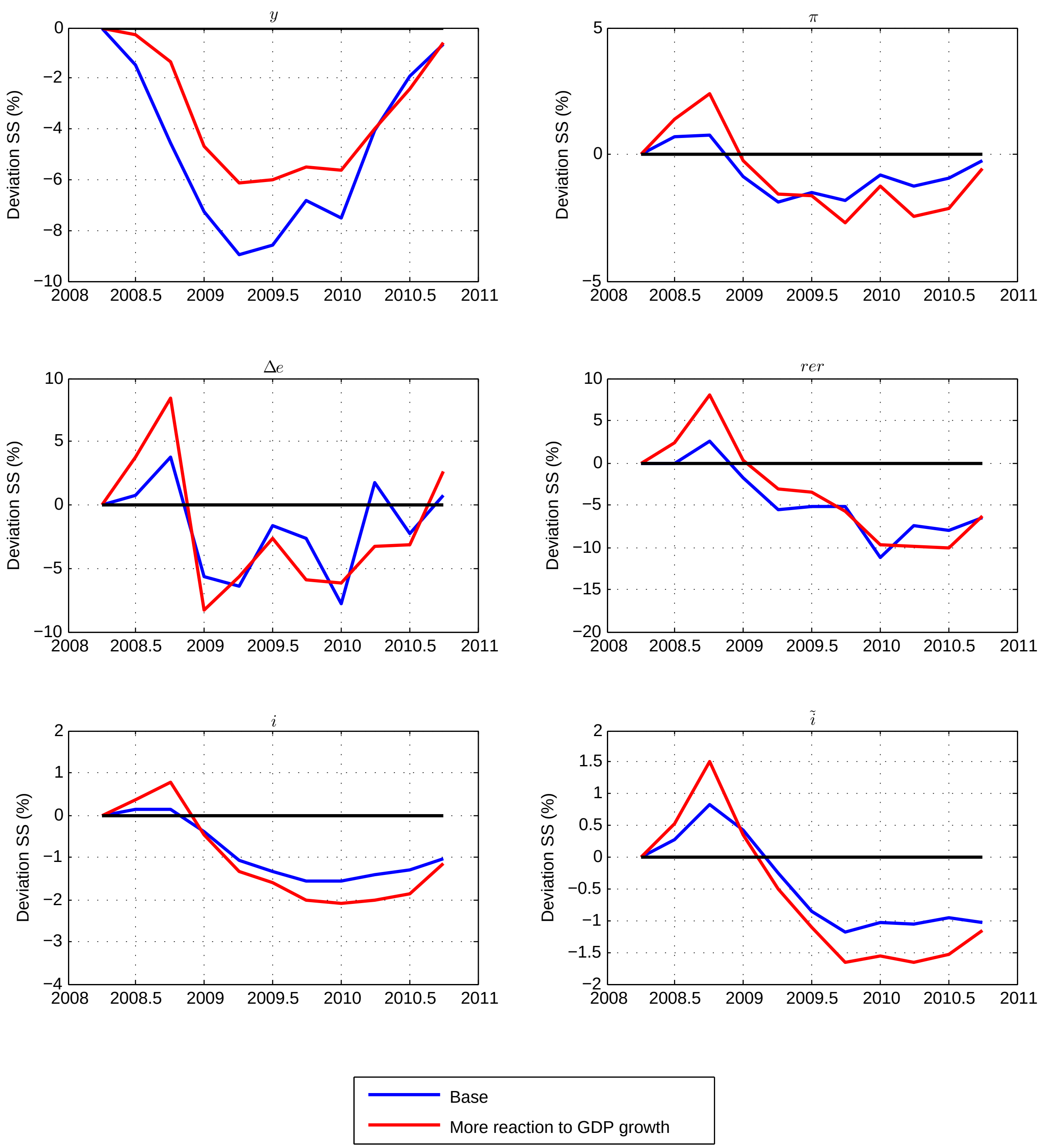

Figure 13: GDP Growth: Historical Decomposition (Alternative Set of Observables)